Implementation of massive transfusion protocols to guide practice in severe bleeding - is your institution ready?

Ryan Zarychanski MD MSc
University of Manitoba
Sections of Hematology and Critical Care
Objectives

• Epidemiology of Massive Transfusion

• Evidence to support the use of protocols to improve outcomes in Massive Transfusion

• Steps and infrastructure needed to implement a functional Massive Transfusion Protocol (MTP) in your centre
All bleeding eventually stops

Epidemiology of Massive Transfusion

- Massive transfusion accounts for 3-5% of civilian and 8-10% of military trauma, but has a 30-60% mortality
  - Uncontrolled hemorrhage = most common cause of preventable early death

- Resuscitation with crystalloids/colloids or plasma-poor red cell concentrates causes dilutional coagulopathy

- Conducting a massive transfusion is a COMPLEX medical procedure
  - Health care professionals and hospitals remain ill-prepared for such an event
What is a “Massive Transfusion”

• Replacement of one blood mass, or 10 units of RBCs in a 24 hour period

Dynamic Definitions

• Transfusion of ≥4 PRBC units with 1 hour when ongoing need is foreseeable

• Replacement of 50% of the total blood volume within 3-4 hours
Challenges inherent to the management of severe bleeding

- Complex medical scenarios
- High mortality

Consistently identified weaknesses
- Poor planning
- Poor communication
- Infrequent laboratory monitoring
- Significant delay in ordering/administering plasma
- Failure to prevent hypothermia & low use of fluid warmers
- Early reliance on cryoprecipitate and rescue medications
Massive Transfusion Protocols

**Purpose of an MTP:**
To improve relevant clinical outcomes

- Formalization of an institutional plan or SOP
- Facilitate/protocolize communication
- Ensure frequent laboratory monitoring
- Reduce delay in ordering and administering blood products
- Deliver a reasonable ratio of plasma to red blood cells (FP:RBC)
Are Massive Transfusion Protocols Evidence-informed?

Riskin et al, 2009

- Mortality rate - 45% before MTP implemented
  - 19% post-implementation

<table>
<thead>
<tr>
<th>Product and ratio</th>
<th>Pre-MTP, mean (95% CI)</th>
<th>Post-MTP, mean (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRBCs</td>
<td>23.9 (18.7–29.1)</td>
<td>20.5 (15.5–25.5)</td>
<td>0.34</td>
</tr>
<tr>
<td>FFP</td>
<td>12.3 (9.6–15.0)</td>
<td>10.7 (7.8–13.6)</td>
<td>0.42</td>
</tr>
<tr>
<td>Plt</td>
<td>2.3 (1.7–2.9)</td>
<td>2.8 (1.8–3.7)</td>
<td>0.41</td>
</tr>
<tr>
<td>FFP:PRBCs</td>
<td>1:1.8 (1:1.5–1:2.2)</td>
<td>1:1.8 (1:1.5–1:2.1)</td>
<td>0.97</td>
</tr>
<tr>
<td>Plt:PRBCs</td>
<td>1:1.7 (1:1.4–1:2.1)</td>
<td>1:1.3 (1:1.1–1:1.5)</td>
<td>0.05*</td>
</tr>
</tbody>
</table>

- Improved communication
- Better systems flow and optimize blood product availability
Predefined Massive Transfusion Protocols are Associated With a Reduction in Organ Failure and Postinjury Complications

Bryan A. Cotton, MD, Brigham K. Au, BS, Timothy C. Nunez, MD, Oliver L. Gunter, MD, Amy M. Robertson, MD, and Pampee P. Young, MD, PhD


<table>
<thead>
<tr>
<th></th>
<th>Pre-TEP (n = 141)</th>
<th>TEP (n = 125)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-h survival (%)</td>
<td>61</td>
<td>69</td>
<td>0.185</td>
</tr>
<tr>
<td>30-d survival (%)</td>
<td>37.6</td>
<td>56.8</td>
<td>0.001</td>
</tr>
<tr>
<td>Hospital length of stay, d (±SD)</td>
<td>16.4 (±20.1)</td>
<td>12.0 (±12.1)</td>
<td>0.049</td>
</tr>
<tr>
<td>ICU length of stay, d (±SD)</td>
<td>6.6 (±9.4)</td>
<td>5.0 (±8.3)</td>
<td>0.239</td>
</tr>
<tr>
<td>Ventilator days, d (±SD)</td>
<td>8.2 (±9.7)</td>
<td>5.7 (±7.2)</td>
<td>0.017</td>
</tr>
<tr>
<td>IO blood products, units (±SD)</td>
<td>11.0 U (±SD)</td>
<td>14.7 U (±SD)</td>
<td>0.001</td>
</tr>
<tr>
<td>IO crystalloid, L (±SD)</td>
<td>7.0 L (±SD)</td>
<td>4.8 L (±SD)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>24-h blood products (±SD)</td>
<td>38.7 U (±SD)</td>
<td>31.2 U (±SD)</td>
<td>0.050</td>
</tr>
</tbody>
</table>

SD, standard deviation; IO, intraoperative.
Predefined Massive Transfusion Protocols are Associated With a Reduction in Organ Failure and Postinjury Complications

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**Table 3** Complications Rates Between Groups

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</thead>
<tbody>
<tr>
<td>SIRS (%)</td>
<td>55.3</td>
<td>52.8</td>
<td>0.682</td>
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<tr>
<td>Severe sepsis/septic</td>
<td>19.8</td>
<td>10.0</td>
<td>0.019</td>
</tr>
<tr>
<td>shock (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilator-dependent</td>
<td>62.4</td>
<td>60.8</td>
<td>0.787</td>
</tr>
<tr>
<td>respiratory failure (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilator associated</td>
<td>39.0</td>
<td>27.2</td>
<td>0.041</td>
</tr>
<tr>
<td>pneumonia (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal compartment</td>
<td>9.9</td>
<td>0.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>syndrome (%)</td>
<td></td>
<td></td>
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</tbody>
</table>

**Table 4** Differences in Single System and Multiple Organ Failures

<table>
<thead>
<tr>
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<th>TEP (n = 125)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory failure (%)</td>
<td>62.4</td>
<td>56.0</td>
<td>0.287</td>
</tr>
<tr>
<td>Cardiac failure (%)</td>
<td>39.0</td>
<td>12.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hepatic failure (%)</td>
<td>9.2</td>
<td>3.2</td>
<td>0.045</td>
</tr>
<tr>
<td>Renal failure (%)</td>
<td>6.4</td>
<td>5.6</td>
<td>0.801</td>
</tr>
<tr>
<td>Multiple organ failure (%)</td>
<td><strong>37.2</strong></td>
<td><strong>15.6</strong></td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Exsanguination protocol improves survival after major hepatic trauma

Victor Zaydfudim\textsuperscript{a,*}, William D. Dutton\textsuperscript{a}, Irene D. Feurer\textsuperscript{a,b}, Brigham K. Au\textsuperscript{a}, C. Wright Pinson\textsuperscript{a}, Bryan A. Cotton\textsuperscript{c,d}


<table>
<thead>
<tr>
<th></th>
<th>Pre-TEP ($n = 39$)</th>
<th>TEP ($n = 36$)</th>
<th>$p$-Value</th>
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</thead>
<tbody>
<tr>
<td>Intra-operative mortality\textsuperscript{a}</td>
<td>13 (33)</td>
<td>8 (22)</td>
<td>0.28</td>
</tr>
<tr>
<td>24-h mortality\textsuperscript{a}</td>
<td>19 (49)</td>
<td>13 (36)</td>
<td>0.27</td>
</tr>
<tr>
<td>30-day mortality\textsuperscript{a}</td>
<td>27 (69)</td>
<td>17 (47)</td>
<td>0.05</td>
</tr>
<tr>
<td>Intra-operative pRBC\textsuperscript{b}</td>
<td>12 (8–16)</td>
<td>12.5 (7.5–20.5)</td>
<td>0.78</td>
</tr>
<tr>
<td>Intra-operative FFP\textsuperscript{b}</td>
<td>4 (3–7)</td>
<td>8 (4–12)</td>
<td>$&lt;0.01$</td>
</tr>
<tr>
<td>Intra-operative platelets\textsuperscript{b}</td>
<td>1 (0–2)</td>
<td>2 (1–4)</td>
<td>$&lt;0.01$</td>
</tr>
<tr>
<td>Intra-operative crystalloid (L)\textsuperscript{b}</td>
<td>6 (4–10)</td>
<td>4 (2.5–6)</td>
<td>$&lt;0.01$</td>
</tr>
<tr>
<td>24-h pRBC\textsuperscript{b}</td>
<td>19 (14–26)</td>
<td>16 (10–24)</td>
<td>0.20</td>
</tr>
<tr>
<td>24-h FFP\textsuperscript{b}</td>
<td>10 (5–20)</td>
<td>10 (8–14.5)</td>
<td>0.72</td>
</tr>
<tr>
<td>24-h platelets\textsuperscript{b}</td>
<td>5 (2–14)</td>
<td>3 (1.5–5.5)</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Who uses MTPs

• 85% of U.S. level I trauma centres have an MTP
• Overwhelming majority of Canadian academic centres have MTPs
  • Considerable variation exists among specific protocols
    • From buried policy documents on the ‘F:\’ drive to complex integrated system processes
• Lack of high quality data to inform optimal design and implementation
Canadian content

- Sunnybrook
  - Code Omega
  - Physician order sheet
    - Hourly blood work
    - 1:1:1 ratio of RBC:FP:PLT
    - Dedicated porters for blood and coag testing
      - 2 minute INR/aPTT spin time
    - Tranexamic acid incorporated (CRASH-2 trial)
    - No routine administration of cryoprecipitate
    - Termination?
    - Evaluation?
Canadian content

• Nova Scotia
  – Province wide initiative with stakeholders
    • Toolkits with physician orders, laboratory SOPs, and data collection instrument
    – Does not include cryoprecipitate, but does include Factor VIIa

Important limitations:
  – Not integrated with laboratory testing
  – Unclear systems processes to ensure transport of blood and coag samples
  – Only blood is mandated in the orders
  – Audit/evaluation?
MASSIVE TRANSFUSION ALGORITHM

IDENTIFY AND TREAT ACTIVE BLEEDING
(Obstetrical, Surgical, Trauma, Medical)

STABILIZE AND TRANSPORT TO REFERRAL CENTRE
Care should be initiated within the resources and capabilities of the sending institution, which will vary depending upon the hospital.

ACTIVATE MTP if patient is bleeding with anticipation of ongoing blood loss or bleeding requiring at least four (4) units of RBCs (adults) or 40 mL/kg (children) in four (4) hours.
- Establish or assign patient identification
- CALL BLOOD TRANSFUSION SERVICE (BTS) TO ACTIVATE MTP
  - Provide contact information of physician leading the MTP
  - Provide patient information
  - BTS will notify the BTS Medical Director as appropriate

MEDICAL-SURGICAL INTERVENTIONS
- Prior to initiation of treatment, send STAT:
  - CBC, INR/PTT, Fibrinogen, Electrolytes, Creatinine, Ionized Ca++, Mg++, serum lactate, Group and Screen, Blood Gas
  - (blood work done based on facility's capabilities)
- Consider cell salvage
- Warm all fluids
- Perform appropriate surgical/interventional radiology interventions in order to control bleeding
- Anticoagulant reversal
  - Oral anticoagulants (e.g. Coumadin®)
  - Octaplex® 40 mL IV AND Vitamin K 10 mg IV
  - Hæsolin-Protamine 1 mg for every 100 U Heparin IV

INITIAL TRANSFUSION MANAGEMENT:
Adults:
- RBCs 6 units
- Plasma 1500 mL and
- Platelets* 1 unit
Pediatrics:
- RBC 15 mL/kg and
- Plasma 10-15 mL/kg and
- Platelets* 5-10 mL/kg
*In hospitals where platelets are not inventoried, if the patient will be managed onsite, consider requesting platelets from OBS.

REASSESS
- CBC, INR/PTT, Fibrinogen, Blood chemistries as appropriate

CONSIDER DISCONTINUING BLOOD COMPONENT THERAPY WHEN:
- Shock has resolved and bleeding is under control
- Inform BTS upon termination of the MTP

FOR ONGOING BLEEDING
Repeat blood components based on lab results and in consultation with BTS.
Consider:
- Antifibrinolytics
- Transaminase - 10 mg/kg IV
- Other Hemostatic Drugs
  - DDAVP - (max 30 mcg)
  - Adults: 10.0 mcg/m² IV
  - Pediatrics: 0.4 mcg/kg IV
- Recombinant Factor VIIa
  - 0.020-0.050 mg/kg IV Direct

MAINAIN:
- Hemoglobin above 70 g/L with:
  - RBCs - Adults: 2-3 units
  - Pediatrics: 15 mL/kg
- Platelets above 75 x 10⁹/L OR above 100 x 10⁹/L (CNS Injury) with:
  - Platelets - Adults: 1 unit
  - Pediatrics: 5-10 mL/kg
- INR below 1.7 with:
  - Plasma - Adults: 500-1500 mL
  - Pediatrics: 10-15 mL/kg
- Fibrinogen above 1.0 g/L with:
  - Cryoprecipitate - Adults: 10 units
  - Pediatrics: 1 unit/10 kg

Print1109_12_10
NSPBCP Guideline for Massive Transfusion in Nova Scotia  November 2010

www.gov.ns.ca/health/nspbcp/
Do we need an MTP in Winnipeg? Results of a retrospective cohort study

- Cardiothoracic Surgery: 34%
- GI hemorrhage: 20%
- Trauma: 15%
- Vascular Surgery: 12%
- Other surgery: 3%
- Obstetrical: 3%
Do we need an MTP in Winnipeg?  
Results of a retrospective cohort study

<table>
<thead>
<tr>
<th></th>
<th>N=218</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Red blood cells</strong></td>
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</tr>
<tr>
<td>Patients receiving emergency RBCs</td>
<td>61 (28.0%)</td>
</tr>
<tr>
<td>Mean # of total RBC units transfused</td>
<td>16.2 units (±6.1)</td>
</tr>
<tr>
<td><strong>Frozen plasma (mean, SD)</strong></td>
<td>12.7 units (±8.0) (~3.0 L)</td>
</tr>
<tr>
<td><strong>Platelets (mean, SD)</strong></td>
<td>15.3 units (±8.9)</td>
</tr>
<tr>
<td><strong>Use of cyroprecipitate</strong></td>
<td></td>
</tr>
<tr>
<td>Use of factor VIIa (n %)</td>
<td>100 (46%)</td>
</tr>
<tr>
<td></td>
<td>47 (21.6%)</td>
</tr>
</tbody>
</table>
Do we need an MTP in Winnipeg? Results of a retrospective cohort study

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Use of a blood warmer?</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>How long does it take to receive product?</td>
<td></td>
</tr>
<tr>
<td>From emergency RBCs to cross-matched RBCs (n=61)</td>
<td>121 minutes [73, 310]</td>
</tr>
<tr>
<td>From first RBC to plasma</td>
<td>175 minutes [90, 395]</td>
</tr>
<tr>
<td>From first RBC to platelets</td>
<td>330 minutes [185, 615]</td>
</tr>
</tbody>
</table>
Do we need an MTP in Winnipeg? Results of a retrospective cohort study

![Graph showing FP:RBC ratio over time (hours)]
Maintenance of adequate HEMOGLOBIN

Minimum recommended target in massive transfusion
Maintenance of adequate PLATELET count

Minimum recommended target in massive transfusion

Percent

< 150 x10e9
< 100 x10e9
< 50 x10e9

65%
Maintenance of an adequate INR

Minimum recommended target in massive transfusion

- > 1.0: 90%
- > 1.5: 67%
- > 2.0: 30%
- > 3.0: 10%
“Houston, we have a problem.”

© Original Artist
Implementation of Winnipeg’s MTP

- Problems were quantifiably obvious
- Requires a comprehensive solution
- The MTP would need to integrate multiple processes:
  - Lab, Blood Bank, CBS, and clinical care areas
  - PLUS – communication and coordination

- Protocol development with stakeholder engagement
- Hired a Process engineer & Project Manager
- Formalized a protocol & charter with Executive support
Process frameworks for change: Lessons from Manufacturing

**Lean**
- A process to identify and eliminate non-value added activities (waste), inefficiency and errors, in our day to day work
- Aim is to improve flow, quality, costs, efficiencies and service delivery without compromising safety

**6 Sigma**
- Improve the quality of process outputs by identifying and removing the causes of error
- More ‘quantitative and analytic approach - DMAIC cycles
- Continuous efforts to achieve stable and predictable results
Process frameworks for change: Lessons from Manufacturing

**Lean – Examples of Waste**
- Defects
- Overproduction
- Waiting
- Non-utilized Talent
- Transportation
- Inventory
- Motion
- Extra Processing

**6 Sigma – DMAIC cycles**
- Define
- Measure
- Analyze
- Improve
- Control
Process frameworks for change: Combining the best of both worlds

- Lean / Six Sigma approach – Winnipeg MTP strategy
  - Eliminate Non-Value Added Activities
  - Waste reduction
  - DMAIC cycles
    - **Define** – problems, opportunities and goals; understand the voice of the customer
    - **Measure** – map processes, establish baseline performance
    - **Analyze** – analyze data to establish root causes
    - **Improve** – brainstorm solutions, implement and test (PDSA cycles)
    - **Control** – ensure changes ‘stick’ and become usual practice
‘The’ Plan

• Protocol development with stakeholder engagement
• Hired a Process Engineer / Project Manager
• Formalized a charter with Executive support
• Initial meeting of stakeholders to review the goal
• Creation of 4 parallel working groups
  – Communications and Transport
  – Blood bank / CBS
  – Diagnostic services (the lab)
  – Clinical care areas (OR, ER, ICU, OBS)
The Plan (cont.)

- Created process maps in each area
- Assessed and measured baseline practice
- Instituted DMAIC cycles for each working group

To follow:
- Education and roll out using evidenced-informed knowledge translation strategies
- Performance evaluation
- Reporting and publication
Implementing an MTP: Are you ready?

• Who are the target patients and target health care professionals?
• Who and how will the protocol be activated?
• How will communication lines be established and maintained?
• How will blood samples be collected, transported, processed, & reported in a timely fashion?
• What ratio of RBC:FP:PLT will you target?
• How will the protocol be terminated?
• How will you evaluate the success of the protocol?
Implementing an MTP: Is your institution ready?

- Have you engaged all relevant stakeholders?
- Do you have the support of upper management?
- Clearly define your goals
- Strongly consider input from a Process Engineer / Project Manager
- How will you measure success?
- How will you ensure changes are sustainable?
Objectives

• Epidemiology of Massive Transfusion

• Evidence to support the use of protocols to improve outcomes in Massive Transfusion

• Steps and infrastructure needed to implement a functional Massive Transfusion Protocol (MTP) in your centre
Questions?
Massive Blood Transfusion Order Set

Intended for use in patients 16 years of age or greater

These orders are to be used as a guideline and do not replace sound clinical judgment and professional practice standards. Patient allergy and contraindications must be considered when completing these orders.

Standard orders. If not in agreement with an order, cross out and initial. □ Requires a check (√) for activation.

<table>
<thead>
<tr>
<th>Drug Allergies</th>
<th>ORDER TRANSCRIBED AND ACTIVATED</th>
<th>DATE</th>
<th>TIME</th>
</tr>
</thead>
</table>

Patient’s Height ____________________________

Patient’s Weight ____________________________

<table>
<thead>
<tr>
<th>MEDICATION ORDERS TO BE INITIATED OR DISCONTINUED</th>
<th>GENERAL ORDERS</th>
</tr>
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Criteria for activating the Massive Transfusion Protocol (MTP):
Transfusion of greater than or equal to 4 RBC units within 1 hour when ongoing need is expected

1. □ Activate Massive Transfusion Protocol (MTP) order set
2. ■ Physician or physician’s designate will Inform Transfusion Medicine Doctor on call that the MTP has been activated
3. ■ Reverse anticoagulation if the patient is systematically anticoagulated
   (See Appendix II for specific drugs and doses)

Perform Initial Resuscitation
- Establish large bore IV access (e.g., a Cordis, Vascath, or 14 - 16 gauge peripheral IVs). A triple lumen central venous catheter or a PICC line are NOT recommended
- Resuscitate with readily available IV fluids to provide adequate blood volume replacement (e.g., target systolic BP greater than 90 mmHg)

■ Collect Baseline Blood work - STAT
   - Type and Screen
   - CBC
   - Electrolytes/biochemistry
IF RBCs or plasma are required IMMEDIATELY and the type and screen is UNKNOWN:

4. □ Transfuse 4 units of Emergency group O red blood cell units
   *Use O negative blood for females less than 45 years of age. For all other patients, O positive units is preferred*

5. □ Transfuse 1000 mL of AB plasma

6. ■ Transfuse the first Massive Transfusion Pack (it will be sent automatically from hospital blood bank). The pack will contain:
   - 6 units red blood cells
   - 1000 mL frozen plasma

- [Na⁺, Cl⁻, K⁺, Ca²⁺, HCO₃⁻; glucose, urea, creatinine, albumin]
- INR/aPTT
- Fibrinogen

■ Use a Fluid/Blood warmer to prevent hypothermia

■ Use forced air heater, or an alternate method of warming if temperature is less than 37 degrees Celsius at any time

□ Transfuse blood products using a pressure bag or a rapid transfuser device

□ Call perfusionist on call to initiate cell salvage (if in an operative setting)
Massive Blood Transfusion Order Set

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### Drug Allergies

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|薬物過敏症 |          |      |

### Medication Orders

To be initiated or discontinued

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
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<tbody>
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<table>
<thead>
<tr>
<th>薬物処方</th>
<th>処方確認</th>
<th>時間</th>
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</table>

7. If additional products are necessary in the first MTP, please order these below:

- [ ] _______ dose(s) of adult pooled platelets
  Consider platelet transfusion if the patient is known to be thrombocytopenic (<50 x10⁹/L) or if platelet dysfunction is suspected (e.g., patient on clopidogrel, IIb/IIIa inhibitors or post cardiopulmonary bypass)
  (Usual practice is 1 adult dose)

- [ ] _______ mL of frozen plasma
  (Consider additional plasma if initial INR is greater than 2.0 or coagulopathy is highly suspected)
  (Usual dose is 15 mL/kg or 1000 - 1500 mL)

### General Orders

**Haemostatic Monitoring during Massive Blood Transfusion:**

- Complete blood count - every 1 hour
- INR - every 1 hr
- Fibrinogen - every 1 hr
- Na⁺, Cl⁻, K⁺, Ca²⁺, HCO₃⁻, glucose, creatinine - every 2 hrs
- Arterial blood gases PRN (at least hourly)
- Temperature every hour OR continuous temperature monitoring

**Goals of Therapy**

- Adequate blood volume replacement
8. Transfuse subsequent Massive Transfusion Packs as they arrive. Packs will arrive hourly and will contain:
   - 1000 mL frozen plasma
   - 1 adult dose of platelets
   - 6 units of red blood cells

Priority for order of transfusion is frozen plasma, followed by platelets, and then RBCs

USE SEPARATE BLOOD COMPONENT ORDER SHEETS (APPENDIX I) IF ADDITIONAL RED BLOOD CELLS, PLATELETS, FROZEN PLASMA OR CRYOPRECIPITATE ARE REQUIRED

(CVP greater than 6 and BP greater than 90 mmHg)

b. Maintain tissue oxygenation
   (provide supplemental oxygen; consider intubation)

c. Prevent acidosis and hypothermia
   (Maintain pH greater than 7.3 and normothermia)

d. Prevent coagulopathy
   (goal INR is less than or equal to 1.4)

e. Achieve haemostasis - EARLY surgical intervention or mechanical means to stop bleeding are STRONGLY recommended. Blood components are only supportive.
9. If the corrected serum calcium is less than 2.1 mmol/L, or if the ABG ionic calcium is less than 1.15 mmol/L, then administer:
   - □ Calcium chloride 1 gram IV (1 ampule) via a **central line**, over 3 - 5 minutes
   - OR
   - □ Calcium gluconate 2 grams IV (2 ampules) via a **peripheral line**, over 3 - 5 minutes each

**Close Out Orders**

As soon as **ONE** of the following criteria has been satisfied:
- Patient has stopped bleeding or bleeding is under control
- The patient has died or resuscitation efforts have been withdrawn
  - □ Physician or Physician’s designate will inform the hospital blood bank that the MTP has ended (73508)
  - □ Promptly return unused blood products to the hospital blood bank

**ORDERING BLOOD COMPONENTS**

**Red Blood Cells**
- Advised to maintain haemoglobin greater than 80 g/L in the face of serious bleeding
- Consider haemoglobin greater than 90 g/L if there is evidence of myocardial ischaemia

**Platelet transfusion**
- Maintain platelets greater than 50 x10⁹/L (greater than 100 in the setting of intracranial or intraocular bleeding)
- Consider empiric platelet transfusion if platelet dysfunction is suspected

**Frozen Plasma**
- Maintain INR less than 1.4
- Transfuse 10 - 15 mL/kg (1000 - 1500 mL)
- Anticipate further needs based on ongoing losses as it can take up to 60 minutes to order, thaw and administer frozen plasma

**Cryoprecipitate**
- *Frozen plasma is the fluid of choice to correct coagulopathy in severe bleeding*
- Cryoprecipitate is RARELY necessary due to the presence of multiple factor deficits that require the administration of plasma to reverse
- If the fibrinogen is less than 1.0 g/L but the INR is greater than 1.5 then is indicated